CLAIMS

1   1.   A method of monitoring turbine engines such as those used in aircraft, comprising the

2   steps of:

3   obtaining sensor signals from an engine for a predetermined set of engine

4   characteristics;

5   transmitting said signals to a nonlinear engine model having predicted values for said

6   predetermined set of engine characteristics and generating residuals by calculating the

7   difference between the actual values and the predicted values for each member of said set;

8   statistically analyzing the generated residuals of each set to estimate bounds of

9   uncertainties as indicative of sensor noise;

10   comparing incoming residuals from ongoing actual engine values against said bounds

11   and signaling a fault for each of said set of characteristics when a detected bound is exceeded;

12   calculating the fault residual for each of said set of characteristics and selecting the

13   closest fault residual as a diagnosed fault.

1   2.   The method of claim 1, wherein said model divides said predetermined sets of

2   characteristics into static modules and dynamic modules.

1   3.   The method of claim 2, wherein said static modules represents major rotating

2   components by maps.

1   4.   The method of claim 3, wherein said static modules calculate power, enthalpy and

2   temperatures for each component.

1 5. The method of claim 2, wherein said dynamic modules determine inter-component
2 pressures by flow balance.

1 6. The method of claim 5, wherein said dynamic modules calculate spool speeds from a
2 power balance.

1 7. A system for monitoring turbineengines such as those used in aircraft, comprising:
2 sensors for obtaining sensor signals from an engine for a predetermined set of engine
3 characteristics;
4 a nonlinear engine model adapted to receive said sensor signals, said model having
5 predicted values for said predetermined set of engine characteristics and adapted to generate
6 residuals by calculating the difference between the actual values and the predicted values for
7 each member of said set;
8 said model further being adapted to statistically analyze the generated residuals of
9 each set to estimate bounds of uncertainties as indicative of sensor noise;
10 said model including a comparator for comparing incoming residuals from ongoing
11 actual engine values against said bounds and signaling a fault for each of said set of
12 characteristics when a detected bound is exceeded; and
13 said model including a calculator for calculating the fault residual for each of said set
14 of characteristics and selecting the closest fault residual as a diagnosed fault.

1 8. The system of claim 7, wherein said model divides said predetermined sets of
2 characteristics into static modules and dynamic modules.

1 9. The system of claim 8, wherein said static modules represents major rotating
2 components by maps.

1   10.   The system of claim 9, wherein said static modules calculate power, enthalpy and

2   temperatures for each component.

1   11.   The system of claim 8, wherein said dynamic modules determine inter-component

2   pressures by flow balance.

1   12.   The system of claim 11, wherein said dynamic modules calculate spool speeds from a

2   power balance.

1   13.   A system for monitoring turbine engines such as those used in aircraft, comprising:

2   sensor means for obtaining sensor signals from an engine for a predetermined set of

3   engine characteristics;

4   a nonlinear engine model means for receiving said sensor signals, said model having

5   predicted values for said predetermined set of engine characteristics and adapted to generate

6   residuals by calculating the difference between the actual values and the predicted values for

7   each member of said set;

8   said model means further being adapted to statistically analyze the generated

9   residuals of each set to estimate bounds of uncertainties as indicative of sensor noise;

10   said model means including a comparator for comparing incoming residuals from

11   ongoing actual engine values against said bounds and signaling a fault for each of said set of

12   characteristics when a detected bound is exceeded; and

13   said model means also including a calculator means for calculating the fault residual

14   for each of said set of characteristics and selecting the closest fault residual as a diagnosed

15   fault.

16

1 14. The system of claim 13, wherein said model means divides said predetermined sets of
2 characteristics into static modules and dynamic modules.

1 15. The system of claim 14, wherein said static modules represents major rotating
2 components by maps.

1 16. The system of claim 15, wherein said static modules calculate power, enthalpy and
2 temperatures for each component.

1 17. The system of claim 14, wherein said dynamic modules determine inter-component
2 pressures by flow balance.

1 18. The system of claim 17, wherein said dynamic modules calculate spool speeds from a
2 power balance.